



## PhD Cifre

### **Giant magnetoresistance for local characterization of surface magnetic state: towards Non-Destructive Testing (NDT) applications.**

#### **Offer description:**

Cifre thesis in the field of non-destructive testing using magnetic sensors in collaboration between 3 partners:

- the Nanomagnetism and Oxide Laboratory (LNO) at CEA Paris-Saclay
- the Electrical Engineering and Ferroelectricity Laboratory (LGEF) at INSA Lyon
- the company CmPhy

**Start date:** October 2023.

**Duration:** 3 years

**Field of research:** magnetic sensors, material properties, electromagnetic simulations, non-destructive testing

The vast majority of structural and construction steels used by the transport, energy and building industries are ferromagnetic. These steels have the property of magnetizing under the effect of an external field and retaining a magnetic state when it disappears.

Mechanical properties and microstructure are strong markers that enable us to anticipate the state of degradation of these steel parts. This information is fundamental to both production and maintenance, and can be read indirectly and non-destructively by observing magnetic behavior.

In this thesis, we propose to develop magnetic sensors of the giant magnetoresistance (GMR) type to trace the surface magnetic state and indirectly the residual stresses, microstructure and level of degradation.

The use of the giant magnetoresistance (GMR) effect, based on spin electronics, enables the development of innovative, highly sensitive magnetic sensors, detecting magnetic fields in the nT/VHz range. They can be submicron in size, making them ideal for surface characterization. Their sensitivity is such that the effect of the earth's magnetic field is sufficient to induce a measurable magnetic response. This opens up the possibility of a lightweight magnetic NDT system that does not require an inductor to generate the field.

The two main applications associated with this thesis will be:

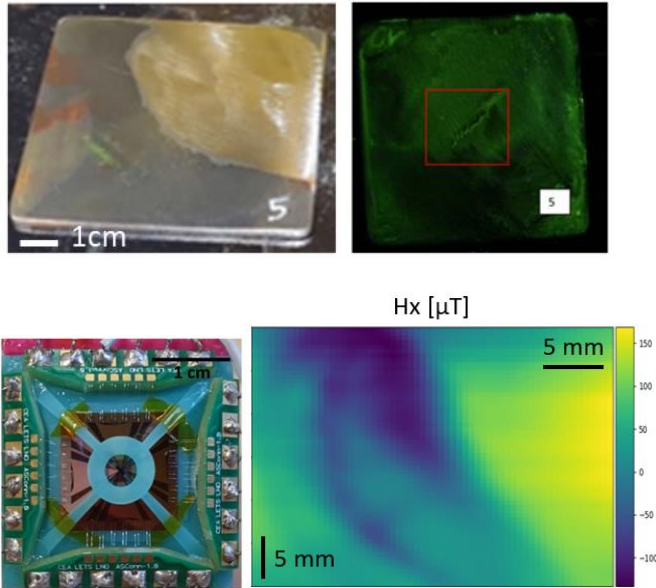
- Detection of surface or subsurface defects (in the mm range).
- Detecting local microstructural variations, surface stresses or plastic deformations.

Several aspects will be covered during the thesis. An integration part, with the aim of developing a demonstrator (interest in this demonstrator has already been expressed by major industrial groups such as Framatome, EDF, DGA, SAFRAN, etc.). Upstream measurements on test samples and in real-life conditions will be carried out to validate the technique. In parallel, a modeling tool for signal analysis will be developed to understand and interpret the results.

The proposed CIFRE financing is based on collaboration between 2 academic laboratories (the Nanomagnetism and Oxide Laboratory (LNO) at CEA Paris-Saclay, specializing in magnetic sensors, and the Electrical Engineering and Ferroelectricity Laboratory (LGEF) at INSA Lyon, specializing in magnetic

materials and their applications) and a company, CmPhy, which designs and manufactures NDT analysis and control equipment, as well as magnetic characterization benches.

### Example of possible project



Magnetic mapping (bottom right) of a steel plate with an internal defect (top photos) using a probe with magnetoresistive sensors (bottom left).

### Expected profile

The candidate must hold a Master 2 degree in physics (condensed matter, materials, sensors, etc.) or electronics/instrumentation. He/she may have theoretical (or even experimental) experience in magnetism, materials properties, electronics and instrumentation. A strong taste for experimentation will be appreciated. Skills such as magnetotransport characterization, device testing, electromagnetic simulations, non-destructive testing techniques and electronics may be particularly relevant.

### Contact and application

Applications should include a cover letter, CV and a copy of the M2 internship report or equivalent. Letters of recommendation may also be included.

For further information on the position or to apply, please contact  
Aurélie Solignac, tel: +33-(0)169089540, email: [aurelie.solignac@cea.fr](mailto:aurelie.solignac@cea.fr)  
Benjamin Ducharne, [benjamin.ducharne@insa-lyon.fr](mailto:benjamin.ducharne@insa-lyon.fr)  
Arnaud Pelletier, [arnaud.pelletier@cmphy.fr](mailto:arnaud.pelletier@cmphy.fr)